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(54) IMPROVEMENTS IN OR RELATING TO RADIO FREQUENCY TRANSMISSIONS SYSTEMS

(71) We, THE ELECTRICITY COUNCIL, a British Body Corporate, of 30 Millbank, London SW1P 4RD, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to radio frequency transmission systems.

It is often desirable, particularly with radio telephone systems, to extend the region covered by the system to be greater than the region covered by a single transmitter. In such cases two or more transmitters may be required all arranged to transmit the same audio information. If the carrier frequencies of the transmitters are in the same radio frequency band, problems are normally encountered in those regions where signals can be received simultaneously from two transmitters, due to interference between the signals. Two radio frequency signals are considered to be in the same band if the carrier frequency of one signal falls within the band-width, occupied by the carrier and sidebands, of the other signal. No problems arise if the carrier frequencies of the transmitters are in distinct frequency bands, e.g. separated by twice the sideband width or more. However such an arrangement is extravagant in its use of the available radio frequency spectrum and is thus undesirable and contrary to modern practice. It is known to employ high stability transmitters having definite frequency offsets of a few hertz, and this arrangement can avoid the extremes of destructive interference. However, for radio frequency signals received simultaneously with equal amplitudes, the combined signal is modulated at the difference frequency, or beat frequency, of the two transmitters.

The present invention sets out to reduce the effects of destructive interference between two radio frequency signals in the same frequency band received simultaneously.

In accordance with the present invention a radio frequency transmission system comprises at least two spaced apart transmitters each arranged for transmitting radio frequency signals in a common frequency band and modulated with the same audio information, for reception of the audio information over a region including an overlap region where the radio frequency signals from two said transmitters are receivable simultaneously, the system having means for providing first and second audio information signals each representing said audio information, means for supplying said audio information signals for modulating the radio frequency signals of respective ones of said two transmitters, and means for applying a time delay in a range as hereinafter defined between said audio information signals. In the overlap region, the simultaneous reception of the radio frequency signals from said two transmitters produces in the receiver a combined radio frequency signal which includes the effects of interference between the two distinct signals. The time delay between the audio information signals of the two received radio frequency signals has the effect in each sideband of the radio frequency spectrum of the combined radio frequency signal, of a comb filter having at null spacing of $1/\tau$, where τ is the time delay, and moving through the sideband at a rate approximately equal to $\Delta f/\tau$, where Δf is the difference between the carrier frequencies of the two radio frequency signals. Thus, although the combined radio frequency signals suffers some effects from the interference of the two radio frequency signals, the whole sideband of the combined signal is never completely cancelled. However, it can be seen that the null spacing of the comb filter response, i.e. the value $1/\tau$, should not be too large relative to the width, in frequency space, of the sideband

containing transmitted information. From another point of view, the reduced response band on each side of a null in the comb filter response should be small relative to the width of the sideband. The smallest value of the time delay τ, which is useful in the performance of the present invention depends on various factors including the nature and band width of the audio information to be transmitted, the type of modulation and detection being used, and the signal to noise level in the received radio frequency signals. Generally, the lower end of the range of the time delays for the invention is the shortest delay which provides a discernable improvement in the intelligibility of the received audio information in the overlap region of the two transmitters, compared with zero time delay. The lower end of the range can readily be ascertained empirically in any particular set up for speech communication, a minimum of one millisecond and preferably 2.5 milliseconds is considered suitable.

The upper limit of the time delay range is set by the maximum time delay between two similar audio information signals of equal amplitude which can be tolerated when the two signals are added together, before the echo effect in the combined signal becomes objectable. On this criterion an upper time delay range limit of about 50 milliseconds and preferably 30 milliseconds is considered suitable.

The transmission system of the invention can be used with any form of non-digital modulation, but is especially useful with amplitude modulation (AM) and related modulation systems such as single sideband (SSB), double sideband suppressed carrier (DSBSC) and double sideband diminished carrier (DSBDC). However, where the transmitted modulated radio frequency signal includes a carrier signal this carrier will itself suffer cancellation in the overlap region of the two transmitters so that the received combined carrier will beat at a rate Δf. Accordingly, if envelope detection is used there will be severe distortion of the audio information at the nulls in the combined carrier. Preferably, therefore, the transmission system, employing amplitude modulation is used in combination with at least one receiver in the overlap region having a carrier reinsertion detector.

Further, with DSBSC signals, the combined signal at the receiver may suffer from sideband asymmetry. As a result, difficulty may be experienced in regenerating the carrier from the sidebands alone, with sufficient reliability. Accordingly, the system is preferably used only with AM modulation, with full or diminished carrier, or with SSB.

The transmission system may include three or more said spaced apart transmitters with reception overlap regions for respective pairs of said transmitters, in which case the system may have means for providing further audio information signals for respective said transmitters and said means for applying a delay may include means for applying such a delay between the audio information signals supplied to the transmitters of each said pair. In this way, the intelligibility of received audio information in any of the overlap regions of the transmitters is enhanced.

In one arrangement, the reception region of the transmitters includes a common region in which the radio frequency signals of all the transmitters are receivable simultaneously, and the system includes a receiver in this common region, each of the transmitters forming part of a repeater station including a receiver for receiving and demodulating radio frequency signals for providing a respective said audio information signal.

The present invention further envisages a method of transmitting common audio information from at least two spaced apart transmitters as modulation of respective radio frequency signals in a common frequency band, so that the transmitted audio information is receivable over a region including an overlap region where the radio frequency signals from two said transmitters are receivable simultaneously, the method including the steps of providing first and second audio information signals each representing said audio information, supplying said audio information signals for modulating the radio frequency signals of respective ones of said two transmitters, and applying a time delay in a range as hereinbefore defined between said audio information signals. Examples of the present invention will now be described making reference to the accompanying drawings in which;

Figure 1 is a schematic diagram illustrating a transmission system embodying the present invention and having three fixed spaced apart transmitters transmitting the same audio information in a common radio frequency band;

Figure 2 is a schematic diagram of a different transmission system, in which signals from a mobile transmitter are received and retransmitted to a base station simultaneously by at least two spaced apart repeater stations;

Figure 3 is a graphical representation of the two sidebands of a combined radio

frequency signal taken at two instants in time and serving to illustrate the operation of the present invention, and

Figure 4 is a further graphical representation of the points along the frequency spectrum of the transmitted audio information at which, in one example, maximum beating can occur in a received signal.

Referring initially to Figure 1, there is illustrated a radio frequency transmission system comprising three spaced apart transmitters 10, 11 and 12, and a control point 13. The three transmitters 10, 11 and 12 are all arranged to transmit radio frequency (r.f.) signals in the same frequency band, i.e. of the same nominal frequency. However there is no need for exceptional measures to be taken to ensure exact correspondence between the transmitter frequencies or indeed precise synchronism. The transmitters 10, 11 and 12 are each arranged to receive the same audio information over respective links 14, 15 and 16 from the base station 13 and to modulate their respective radio frequency signals with this information. As a result, the area or region covered by the transmission of the three transmitters 10, 11 and 12, that is the region over which the transmitted audio information is receivable from any of the transmitters, is considerably greater than the region covered by each transmitter alone. The advantages of such a multi-transmitter system are well known. However, as is also well-known, problems normally arise in the overlap regions where the signals from two transmitters can be received simultaneously.

Referring again to Figure 1, a portion of the edge of the region covered by each of transmitters 10, 11 and 12 alone is indicated at 17, 18 and 19 respectively. As shown, the various regions overlap, so that transmitters 10 and 11 have an overlap region 20, transmitters 11 and 12 have an overlap region 21 and transmitters 12 and 10 have an overlap region 22. Further, there is in this example a region 23 in which signals from all three transmitters may be received simultaneously.

In each of the overlap regions, a receiver, such as at 24, 25, 26 and 27 respectively, will receive simultaneously two or more radio frequency signals from the various transmitters, and the received signals will tend to interfere with one another, unless precisely synchronized. In the absence of special measures, the effect in a receiver will be that the combined received signal will beat (or fade) at a rate equal to the difference between the carrier frequencies of the two received r.f. signals. In the case of a receiver 27 in the region 23, the combined signal will beat at a complex rate, being a combination of the differences of the carrier frequencies of all three transmitters. This beating or fading effect can render the received audio information unintelligible, especially when the separate received r.f. signals are nearly the same strength. In the example illustrated in Figure 1, this problem is alleviated under most circumstances by arranging to delay the udio information signals, fed to the different transmitters by different amounts. Thus, the control point 13 includes an audio information signal generator 28 connected to supply the audio information signal to three delay units 29, 30 and 31. The delay units 29, 30 and 31 apply time delays τ, τ_2 and τ_3 respectively to the audio information signal and are connected to supply the delayed signals to respective transmitters. Thus, the audio information signal modulating the r.f. signal of transmitter 10 is delayed relative to that of transmitters 11 by τ_1—τ_2. Similarly the delays between the audio information signals sent by transmitters 11 and 12, and transmitters 12 and 10, are τ_2—τ_3 and τ_3—τ_1 respectively.

The way in which the above referred delays alleviate cancellation in the overlap regions 20—23 will be described later herein. However, it is important that the time delay between the audio information signals sent by any two transmitters which have an overlap region is in a predetermined range. The limits of the range are not precise. The longest delay allowable is the maximum delay before any audible echo in the demodulated combined audio information signal becomes excessive so as to impair the intelligibility of the received audio information. Thus the maximum delay should be less than 50ms and preferably less than 30ms.

The shortest delay which is useful in performing the invention is broadly that which gives a discernable improvement in intelligibility. In practice, as will become apparent later herein, the minimum delay should not be so short that the reciprocal of the delay ($1/\tau$) becomes equal to an appreciable fraction of the total frequency spectrum of the audio information being transmitted. Thus, for speech transmission, the minimum delay is about 1ms and preferably 2.5ms.

Thes invention may be employed to advantage in most forms of modulation (AM, SSB, DSBSC, DSBDC), but it is thought not to be applicable to frequency modulation. Further DSBSC is a non-preferred system in view of the difficulty of demodulating the received combined signal. Where the transmitters employ amplitude modulation (AM), it is desirable, in order to achieve the advantages of the invention,

that any receiver for receiving the combined r.f. signals has a carrier reinsertion demodulator.

The system illustrated in Figure 1 is primarily an area coverage system for transmitting audio information from a single control point over an area, *via* several relatively low power transmitters, e.g. to a mobile receiver. Another example of the invention, illustrated in Figure 2 provides for reception of signals transmitted, e.g. by a mobile transmitter, over an area greater than the range of the transmitter would permit to a single receiver. To provide increased reception area coverage, three repeater stations 40, 41 and 42 are provided at spaced apart locations. Each repeater station has a receiver 43 and a transmitter 44 for relaying signals received, e.g. from a mobile transmitter 44, to a base station receiver 46. The repeater stations are spaced apart to extend the area within which signals from the mobile transmitter 45 can be received by any one of the stations and retransmitted to the base station 46.

The transmitters 44 of the repeater stations all have the same nominal r.f. frequency and it will be apparent that, in some regions, signals from a mobile transmitter will be received by two or more repeater stations simultaneously and, thus, simultaneously, retransmitted to the base station 46. Naturally, the base station 46 is located in the overlap regions of the transmitters of each pair of repeater stations, and accordingly the previously mentioned problems of cancellation can then arise.

In the system of Figure 2, each repeater station includes a delay unit 47, arranged to apply a respective time delay (τ_1, τ_2 and τ_3) to the demodulated audio information signal from the receiver 43 of the station before sending the signal as modulation of the r.f. signal transmitted by the transmitter 44. As in the example of Figure 1, the delays ($\tau_1-\tau_2$, $\tau_2-\tau_3$, $\tau_3-\tau_1$) between the audio information signals sent by the transmitters 44 can alleviate the problem of cancellation at the base station 46.

In a typical arrangement, the delays τ_1, τ_2, and τ_3, in the examples of Figures 1 or 2 may be 0, 10 and 20ms respectively.

There now follows a brief and simplified mathematical explanation of how the invention works. For the purposes of this explanation, two A.M. radio frequency signals of equal strength and equal modulation index, which are received simultaneously, can be expressed as:—

$$S_1 = \cos W_c t + \frac{M_1}{2} \cdot \cos (W_c + W_m)t + \frac{M_1}{2} \cdot \cos (W_c - W_m)t, \qquad (1)$$

where W_c is the carrier frequency, W_m the modulating frequency and M_1 is the modulation depth

and

$$S_2 = \cos\left\{(W_c + \Delta W)t + \theta\right\} + \frac{M_1}{2} \cdot \cos\left\{(W_c + \Delta W + W_m)t + \theta - W_m\tau\right\} + \frac{M_1}{2} \cos\left\{(W_c + \Delta W - W_m)t + \theta + W_m\tau\right\}, \qquad (2)$$

where ΔW and θ are the difference between carrier frequency and phase of the two signals and τ is a time delay between the audio information signals modulating the two carriers. It has been assumed for simplicity that the audio frequency circuits of the two transmitters introduce negligible frequency translation and phase shift between the two signals.

Then, the combined received signal becomes:—

$$\begin{aligned} S_1 + S_2 = {} & 2\cos\left\{\left(W_c + \frac{\Delta W}{2}\right)t + \frac{\theta}{2}\right\} \cdot \cos\left\{\frac{\Delta W}{2} + \frac{\theta}{2}\right\} \\ & + M_1 \cos\left\{\left(W_c + W_m + \frac{\Delta W}{2}\right)t + \frac{\theta - W_m\tau}{2}\right\} \cdot \cos\left\{\frac{\Delta W}{2}t + \frac{\theta - W_m\tau}{2}\right\} \\ & + M_1 \cos\left\{W_c - W_m + \frac{\Delta W}{2}\right)t + \frac{\theta + W_m\tau}{2}\right\} \cdot \cos\left\{\frac{\Delta W}{2} \cdot t + \frac{\theta + W_m\tau}{2}\right\}. \end{aligned} \qquad (3)$$

The first term of expression (3) is the combined carrier at the mean carrier frequency, and has the multiplier

$$\cos\left(\frac{\Delta W}{2}.t+\frac{\theta}{2}\right)$$

Thus, the combined carrier beats to null at the rate

$$\frac{\Delta W}{2\pi}.$$

If envelope detection were used, there would be severe distortion at the carrier nulls and it is therefore desirable to employ a carrier reinsertion detector in the receiver.

The upper sideband term of the expression (3) includes the multiplier

$$\cos\left(\frac{\Delta W}{2}.t+\frac{\theta}{2}-\frac{W_m\tau}{2}\right).$$

Thus, although there is beating at the rate

$$\frac{\Delta W}{2\pi}$$

at any single frequency in the sideband, the phase of the beating is determined by the term

$$-\frac{W_m\tau}{2}$$

and is dependant on the modulating frequency W_m;

Similarly in the lower sideband the phase of the beating is determined by the term

$$+\frac{W_m\tau}{2}.$$

Referring to Figure 3, the effect of the dependence of cancellation on modulating frequency is illustrated. The graphs in the figure are the moduli of the response envelopes across the two sidebands of the combined signal—at times $t=0$ and

$$t=\frac{\pi}{\Delta W}.$$

In the graphs

$$\theta=\frac{2\pi}{3}.$$

The spacing between the nulls at any time is $2\pi/\tau$ radians.

It can be seen that the effect of the delay τ is analagous to a comb filter in the frequency spectrum of the sidebands having a spacing between nulls of $2\pi/\tau$ rads and running through the spectrum, in the direction X of increasing frequency, at the rate $\Delta W/\tau$ radians/sec, so that the response at any particular frequency beats at $\Delta W/2\pi$.

Thus with the delay τ, at no time is the whole of a sideband cancelled. However, it can now be seen that to obtain the advantages inherent in the comb filter effect, the null spacing $2\pi/\tau$ rads should be much less than the bandwidth of the audio information being transmitted, i.e. $1/\tau << $ bandwidth in Hertz. In practice, the chief application of the present invention is in the field of speech radio-telephony, where $1/\tau$ is less than 1KHz and preferably less than 400Hz.

The advantage of the delay τ in a SSB system is quite apparent from the above;

however for AM, DSBSC and DSBDC, the effects of demodulating should be considered.

In the simple case, where a local oscillator in the receiver is synchronous with the carrier signal of one of the two received signals, multiplying the received signal, expression (3), by the local oscillator signal (COS $W_c t$) and filtering out the term with frequency $2W_c$ produces a demodulated signal:—

$$
\begin{aligned}
d(S_1+S_2) &= \cos^2\left\{\frac{\Delta W}{2}.t+\frac{\theta}{2}\right\} \\
&+\frac{M_1}{2}\cos\left\{W_m t-\frac{W_m\tau}{2}\right\}.\cos^2\left\{\frac{\Delta W}{2}.t+\frac{\theta}{2}\right\}.\cos\left(\frac{W_m\tau}{2}\right) \\
&+\frac{M_1}{2}\sin\left\{W_m t-\frac{W_m\tau}{2}\right\}.\sin^2\left\{\frac{\Delta W}{2}.t+\frac{\theta}{2}\right\}.\sin\left(\frac{W_m\tau}{2}\right).
\end{aligned}
\tag{4}
$$

The first term of expression (4) is the beating between the local oscillator and the combined received carrier and can be ignored if the beat frequency

$$\frac{\Delta W}{2\pi}$$

is low relative to the audio information band.

Considering the second and third terms, where

$$\operatorname{Sin}\left(\frac{W_m\tau}{2}\right)=0,$$

i.e. $W_m=0,$

$$\frac{2\pi}{\tau}, \frac{4\pi}{\tau}, \ldots,$$

and the third term is zero and the remaining second term will suffer cancellation or null beating in accordance with the term

$$\mathrm{COS}^2\left(\frac{\Delta W}{2}.t+\frac{\theta}{2}\right),$$

i.e. at a rate

$$\frac{\Delta W}{2\pi}$$

Where

$$\mathrm{COS}\left(\frac{W_m\tau}{2}\right)=0, \quad \text{i.e.} \quad W_m=\frac{\pi}{\tau}, \frac{3\pi}{\tau} \ldots,$$

the second term is zero and the third term suffers concellation in accordance with the term

$$\operatorname{Sin}^2\left(\frac{\Delta W}{2}.t+\frac{\theta}{2}\right), \text{ i.e. at a rate } \frac{\Delta W}{2\pi}.$$

However, in the intervals between the frequencies

$$W_m=0, \frac{\pi}{\tau}, \frac{2\pi}{\tau}, \frac{3\pi}{\tau} \ldots,$$

the received and demodulated signal is never cancelled to zero. Referring to Figure 4,

there is shown, in graphical form, the frequencies in the spectrum of the audio information signal at which the demodulated signal suffers total cancellation. Between these frequencies, though some beating will normally occur, the beating does not produce complete cancellation.

The above mathematical consideration is considerably simplified over what can normally be expected in practice. However, suitable more complex mathematical analysis can be made which indicates that the introduction of the time delay τ improves the likelihood that audio information received in the overlap regions can be made intelligible.

In an experimental arrangement the improvement in performance for a speech radio telephone system was modelled. The experimental arrangement consisted of two r.f. carrier sources, for which the frequency difference

$$\left(\frac{\Delta W}{2\pi}\right)$$

was variable and could be held to be better than 1Hz. Also a carrier phase shifter was included to give a full range of phase differences when operating the two sources synchronously. Two balanced modulators were employed to produce DSBSC signals with carriers 40 db suppressed. The audio signal paths to the modulators included a variable delay unit in one path, giving up to 10 ms delay and a frequency translator capable of introducing between 0.5Hz and 5Hz translation. The two DSBSC modulated r.f. signals were combined together with a controllable amount of white noise from a suitable source. The combined signal was band limited by a band-pass filter, demodulated in a product detector and filtered by a low pass filter. The local oscillator for the detector was separately controllable so that it could be set to the frequency of either r.f. carrier or to the composite carrier frequency, and also shifted in phase.

The criterion used to establish intelligibility of the transmitted speech was the score achieved when subjects listened to lists of phonetically balanced monosyllabic words spoken by a variety of speakers, all with the addition of various levels of white noise.

For a given test configuration, offset frequency ΔW, delay τ, etc, a series of tests were performed at various signal to noise levels to obtain a graph of intelligibility versus signal to noise ratio and from this a s/n ratio was deduced for which 50% intelligibility was achieved.

Table 1 below shows the results obtained comparing no audio delay ($\tau=0$) with $\tau=4.4$ ms and with a female speaker. The test is repeated for various carrier offset frequencies

$$\left(\frac{\Delta W}{2\pi}\right).$$

As a control the test was also repeated using only one r.f. DSBSC signal. The demodulation was performed with the local oscillator running at the carrier frequency of one of the DSBSC signals.

Offset frequency $\Delta W/2\pi$ Hz	S/N for 50% intelligibility *db*		Degradation of un-delayed w.r.t. single signal db	Improvement of delay w.r.t. single signal db
	No Delay	Delay τ = 4.4 ms		
0.5	19.4	12.2	- 6.4	+ 0.8
2	19.7	10.5	- 6.7	+ 2.5
4	23.0	11.3	-10.0	+ 1.7
8	19.8	11.6	- 6.8	+ 1.4
12	24.5	12.3	-11.5	+ 0.7
20	17.0	12.1	- 4.0	+ 0.9
40	12.8	10.0	+ 0.2	+ 3.0
Single Signal	13.0	—	—	—

Thus, from the results in Table 1, the average degradation with no delay ($\tau=0$) was -6.5 db and the average improvement with delay ($\tau=4.4$ ms) was $+1.6$ db.

In the above arrangement with the two carriers synchronous but antiphase, there was complete steady cancellation with no delay ($\tau=0$), but 4.4 ms delay gave 12.7 db S/N for 50% intelligibility, i.e. an improvement of 0.3 db over the single signal condition.

In a second experiment the delay (τ) was increased to 9.4 ms and a male speaker was used. The results are shown in Table 2 below.

Offset frequency $\Delta W/2\pi$ Hz	S/N for 50% intelligibility *db*		Degradation of un-delayed w.r.t. single signal db	Improvement of delay w.r.t. single signal db
	No Delay	Delay τ = 9.4 ms		
0.5	20.2	14.3	- 4.6	+ 1.3
1.0	23.3	14.2	- 7.7	+ 1.4
2.0	19.8	13.8	- 4.2	+ 1.8
4.0	20.9	15.5	- 5.3	+ 0.1
10.0	19.2	13.3	- 3.6	+ 2.3
20.0	17.7	11.0	- 2.1	+ 4.6
40.0	18.3	12.6	- 2.7	+ 3.0
Single Signal	15.6	—	—	—

Thus, from the results in Table 2, the average degradation with no delay ($\tau=0$) was -4.3 db and the average improvement with delay ($\tau=9.4$ ms) was 2.1 db.

In the experimental arrangement of Table 2, with the two carriers synchronous but antiphase, there was complete steady cancellation with no delay ($\tau=0$), but an S/N ratio of 14.5 db with delay ($\tau=9.4$ ms), giving an improvement of 1.1 db over the single signal condition.

The above experiments were intended to confirm the effects of combination of the sidebands when the audio signal was subjected to modulation delay. As already stated the local oscillator was separately controlled. However in practical use the receiver will include a carrier regeneration circuit to operate on a full or diminished transmitted carrier. In the case of SSB the normal stabilities of $\pm$20Hz enable satisfactory demodulation without the transmission or regeneration of carrier.

WHAT WE CLAIM IS:—

1. A radio frequency transmission system comprising at least two spaced apart transmitters each arranged for transmitting radio frequency signals in a common frequency band and modulated with the same audio information, for reception of the audio information over a region including an overlap region where the radio frequency signals from two said transmitters are receivable simultaneously, the system having means for providing first and second audio information signals each representing said audio information, means for supplying said audio information signals for modulating the radio frequency signals of respective ones of said two transmitters, and means for applying a time delay in a range as hereinbefore defined between said audio information signals.

2. A radio frequency transmission system as claimed in claim 1, wherein said time delay is in the range 1ms to 50ms.

3. A radio frequency transmission system as claimed in claim 2 wherein said time delay is in the range 2.5ms to 30ms.

4. A radio frequency transmission system as claimed in any preceding claim wherein the transmitters are arranged to transmit AM, SSB, or DSBDC signals.

5. A radio frequency transmission system as claimed in claim 4 and in combination with a receiver in the overlap region having a carrier reinsertion detector.

6. A radio frequency transmission system as claimed in any preceding claim and including three or more said spaced apart transmitters with reception overlap regions for respective pairs of said transmitters, the system having means for providing further audio information signals for respective said transmitters, and said means for applying a time delay including means for applying such a delay between the audio information signals supplied to the transmitters of each said pair.

7. A radio frequency transmission system as claimed in any preceding claim wherein the reception region of the transmitters includes a common region in which the radio frequency signals of all the transmitters are receivable simultaneously, and the system includes a receiver in this common region, each of the transmitters forming part of a repeater station including a receiver for receiving and demodulating radio frequency signals for providing a respective said audio information signal.

8. A method of transmitting common audio information from at least two spaced apart transmitters as modulation of respective radio frequency signals in a common frequency band, so that the transmitted audio information is receivable over a region including an overlap region where the radio frequency signals from two said transmitters are receivable simultaneously, the method including the steps of providing first and second audio information signals each representing said audio information, supplying said audio information signals for modulating the radio frequency signals of respective ones of said two transmitters, and applying a time delay in a range as hereinbefore defined between said audio information signals.

9. A method of transmitting as claimed in claim 8 wherein said time delay is in the range 1ms to 50ms.

10. A method of transmitting as claimed in claim 9 wherein said time delay is in the range 2.5ms to 30ms.

11. A method of transmitting as claimed in claim 8 and substantially as hereinbefore described with reference to either one of Figures 1 and 2, together with Figures 3 and 4 of the accompanying drawings.

12. A radio frequency transmission system substantially as hereinbefore described with reference to Figures 1 or 2 of the accompanying drawings.

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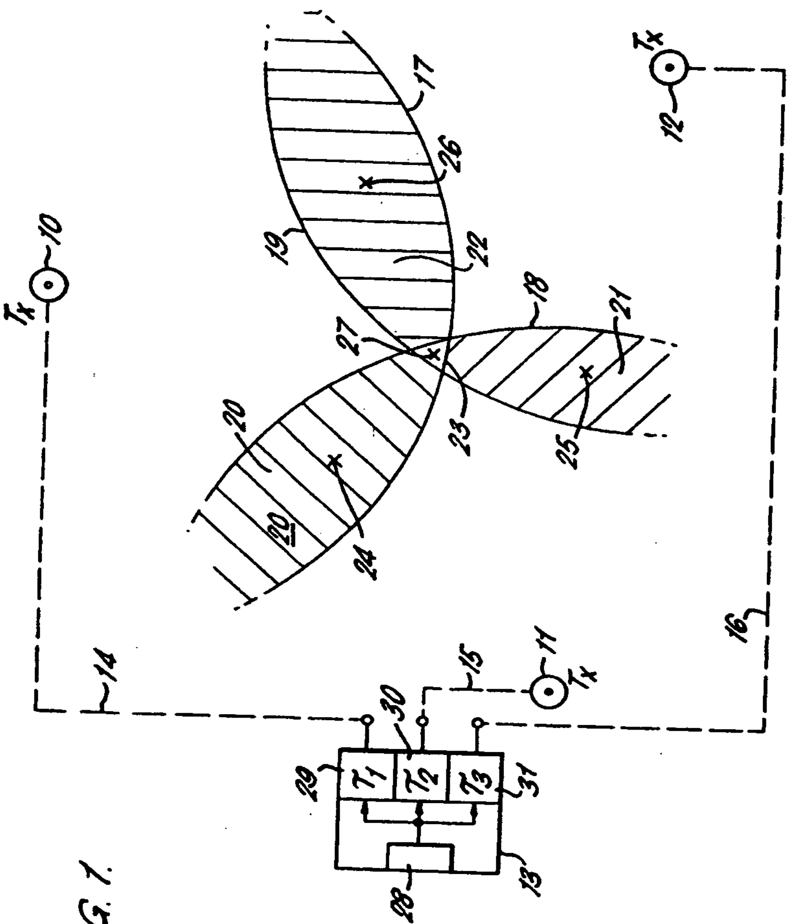
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FIG. 1.

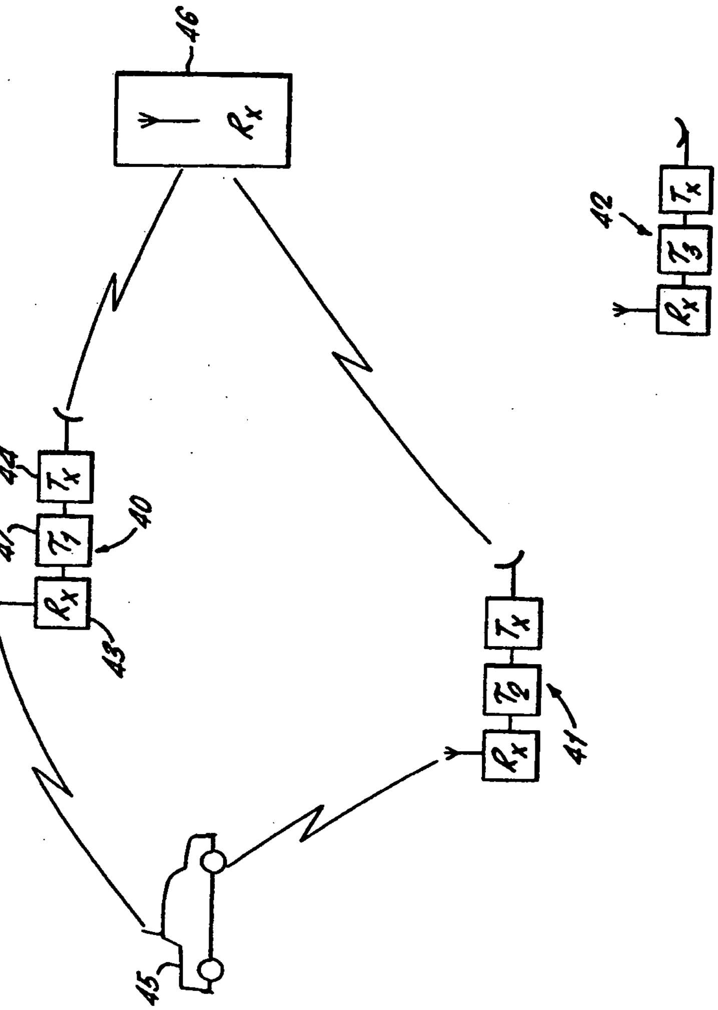

FIG. 2.

1576347 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 3

FIG. 3.

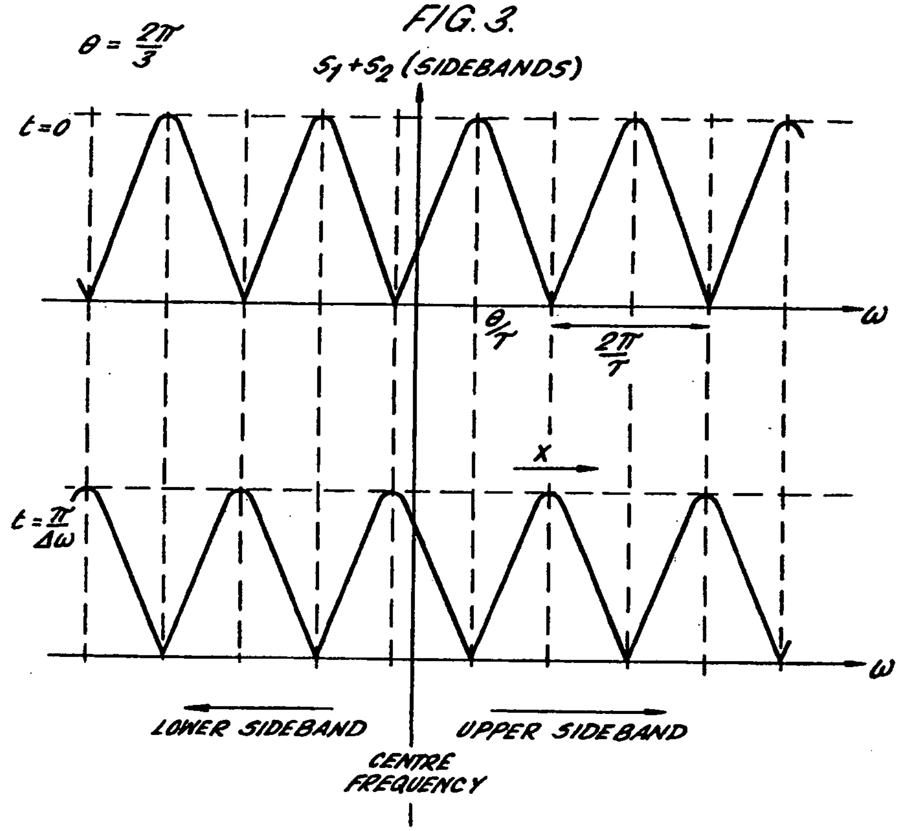

FIG. 4.